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ART. I.—*Annual Report of the President and Directors of the Board of Public Works, to the General Assembly of Virginia, in pursuance of an Act, entitled, An Act creating a Fund for Internal Improvement.* Richmond; 1818. pp. 78.

EVER since our ancestors founded this new family among nations, we have been in a continual bustle and stir to supplant the old tenants, to arrange our great and increasing household, and to dispose of its members among the departments and recesses of this extensive and fair domain. No sooner had a small number fixed themselves in a comfortable situation, than a spirit of inquiry and boldness of enterprise rendered them restless. New discoveries led to new emigration; love of safety and of social ties yielded to a love of territory and power; and the consequent dispersion of the early colonists has been continued among their descendants to the present day, when the limits of our territory and population are scarcely discernible towards the west. It is remarkable, that, in spite of this spreading emigration, which so powerfully counteracts the growth of useful arts, we should, in two centuries, be so little behind Europe, where a thousand years have been spent in labour, invention and experience to bring them to their present state of improvement. But we must not be too proud of our advantages, nor mistake the cause which produced them. We should recollect that Europe has been

at work many ages for our benefit, and that our philosophy, our science, our literature and our arts come from her, ready made up for our use. Our habits, manners, fashions, modes of worship, morals, laws and forms of government, as well as ourselves, have all sprung from the great European fountain, whence has flowed, and still flows, a rich and constant stream of learning and intellect. Our social and moral powers are excited and brightened by the familiar intercourse between this country and Europe; but many of our inventive faculties are inactive, because we have few occasions for invention. In its place, a habit of copying, and of copying well, has grown up with us. Our mechanic arts are devoted to the imitation or manufacturing of articles or fabrics from models taken out of foreign workshops; we make roads and canals, and improve rivers; build docks and improve our harbours, from plans of similar works in France and England. We do all these as the means of acquiring wealth;—in Europe wealth has produced them. Here we endeavour to add them to the natural advantages of our country, and begin in our infancy to construct works, which are there considered as the monuments of extensive opulence, population and refinement.

It is a common remark with writers on political economy, that the division of labour has been the main cause of the rapid improvement of the arts in modern times; but the observation is drawn from, and is seldom extended beyond the workshop. It is to this principle also, and to this alone, that we must look for any progress in the higher branches of knowledge; and in proportion as this principle is understood and applied, will nations improve either in arts or science. It is to the operation of this principle, that the world is indebted for the most philosophic invention of modern times,—the safety lamp of Sir Humphrey Davy. The labours of Perronet, De Prony, Guathey, De Cessart, Brindley, Smeaton, and other engineers, have shown a connexion between natural philosophy and the wealth of nations; between the laws of our necessities and the laws of nature; and taught us to apply the most abstruse mathematical researches to the important and daily occupations of life.

If we examine ourselves as a nation, we shall be at no loss to discover, that it is our limited application of this principle,—the division of labour,—which has placed us behind Eu-

rope in arts, science and literature. But the examination neither excites our regret nor wounds our pride. Industry, in civil society, is as natural as the love of light; it is always striving to multiply and magnify its products, and tends as steadily to separate workmen into classes, as the love of independence to separate them into families. All this, however, is the result of individual, unassociated effort; it is slow, but sure in its progress, and does not spring at once into being, from any combination or compact;—it is founded in self-love, which will act, and which no moral or political power can check or controul. There are other means of promoting the public prosperity, which are not so obvious, and depend in some way or other on the good will, sanction, and assistance of the community. These are the works of ingenious and literary men; of men who study the laws of motion and the constitution of things; who improve our moral capacities; who reveal the occult laws of nature, and instruct us how to apply discoveries in science to the useful arts; who teach us how to think, to reason, to feel, and how to labour and how to be happy; of men who toil for the public, and get little or no return for their exertions.

We would gladly proceed to extend these remarks, and exemplify them in detail; but we must, for the present, forego that pleasure, and introduce to the notice of our readers the important, wise and effectual plan for the improvement of our country, which gave rise to them, and which, in our opinion, is better suited to the existing calls of the nation, and will do more for the encouragement of useful science and for the development of our physical resources, than any institution in the United States.

The Board of Public Works in the State of Virginia, was established by an act of the General Assembly, passed February 1816, entitled 'An Act creating a fund for internal improvement.' Thirteen members constitute the Board, who are called by the act, 'The President and Directors of the Board of Public Works.' Of these, the Governour, the Attorney General, and the Treasurer of the commonwealth are, ex officio, members, and the Governour is the President of the Board. The ten other members are elected annually by the assembly, in certain proportions, from different sections of the state. They hold their annual meetings at Richmond, during the session of the General Assembly, and receive the same

pay and compensation as the members of the House of Delegates. The Board has the controul and management of the fund for internal improvement, which will be presently noticed; they have power to fill any vacancy that may happen during the year, and to appoint a treasurer, secretary, principal engineer and assistants, &c. and to fix the salaries of the different officers. In short, the Board has the usual powers of corporations, and are bound by the act to make an annual report to the Legislature of all their proceedings.

The objects of internal improvement, in aid of which the Board is authorized to subscribe in behalf of the state, are canals, roads, opening river navigation, &c. For these purposes, the act prescribes the circumstances under which the application of the funds shall be made. On the request of any company or commissioners for carrying into effect any project for internal improvement, the Board directs their engineer to make the preliminary surveys, examination, levels and estimates, and if, upon his report, it shall appear to them that the proposed work will be of public utility, and promises a reimbursement, by tolls, &c. of the expense, the Board are allowed to subscribe two fifths of the amount of stock necessary to complete the work. But the most effectual and liberal assistance arises from the condition of this subscription, which is, that no toll, interest or dividend is to be received by the Board on their two fifths, until the other, private stockholders of the company shall have received a net profit of six per cent. on their three fifths of the stock; and when the net proceeds of the work shall amount to more than six per cent. on three fifths of the stock, and not until then, does the public receive any share in the profit.

The first annual report of the Board to the General Assembly was made on the 19th December, 1816. It contains a statement of the funds committed to their management; observations upon the nature of the works which the Board think important to the public; with documents relative to the Little River Turnpike, Dismal Swamp Canal, Appomattox Canal, Potomac Canal, and James River Canal, companies,—together with the resolutions of the Board concerning the objects of primary importance in internal improvement, and the correspondence in which the Board had previously been engaged concerning the election of a principal engineer.

At the date of the report, the funds committed to the Board by government were,

125½	Shares of the stock of the Little River Turnpike Company	$12550.00
70	Shares of the Dismal Swamp Canal Company	17500.00
125	Shares of the Appomattox Company - -	12500.00
70	Do. of the Potomac Canal Company -	31111.11
250	Do. of the James River Canal Company	50000.00
5000	Do. of the Bank of Virginia, denominated old stock	500000.00
547	Do. of do. do. denominated new stock	54700.00
2400	Do. of do. do. on which a dividend accrued after the 1st of May, 1818	240000.00
3334	Do. of the Farmers' Bank of Virginia	333400.00

Making a total amount of $1,251,761.11

Upon the productive part of this stock, consisting of the shares held by the commonwealth in the James River Canal Company, and the Banks of Virginia, there had been received early in July previous, the sum of $32429.50

Out of which there had been disbursed for the salary of the Secretary, and in compensation of the Door-keeper of the Board	$ 112.00	
For the daily pay and travelling expenses of the members of the Board at the extra session thereof in June	402.95	
For stationary and postage - - -	6.06	
And in execution of the act, entitled, an act to provide an accurate chart of each county, and a general map of the territory of the commonwealth	3200.00	= 3721.01
And leaving an excess of revenue, above the expenditure charged upon it		$28708.49

In virtue of a resolution of the Board, the sum of $25887, part of the surplus revenue, was vested in 258 shares of the stock of the Bank of Virginia.

The second annual report of the Board was made in December 1817. The state of the fund on the 1st day of November was as follows;

125½	Shares of stock of the Little River Turnpike Company	$12550.00
70	Do. of stock of the Dismal Swamp Canal Company	17500.00
125	Do. of stock of the Appomattox Canal Company	12500.00
70	Do. of stock of the Potomac Canal Company	31111.11
250	Do. of stock of the James River Canal Company	50000.00
5000	Do. of stock of the Bank of Virginia -	500000.00
547	Do. of stock of the Bank of Virginia New stock	54700.00
2400	Do. of stock of the Bank of Virginia on which a dividend accrued after the 1st day of May, 1818	240000.00
3334	Do. of stock of the Farmers' Bank of Virginia	333400.00
258	Do. of stock of the Bank of Virginia, purchased by order of the Board in November 1816	25800.00
104	Do. of stock of the Bank of Virginia, purchased by order of the Board	10400.00
		$1,287961.11
186	Do. of stock of the Dismal Swamp Canal Company (New Stock) of which has been paid up only as yet	15500.00
	Total	$1,303,461.11

Of the productive part of this stock, consisting of the shares in the Banks of Virginia and James River Company, there has been received, between the first Monday in November 1816, and the first Monday in November 1817,

From the Bank of Virginia - - -	$46648.75
From the Farmers' Bank of Virginia - -	28339.00
From the James River Company - -	8000.00
	82987.75
To which is to be added the sum reported to be in the fund on the 1st day of November, 1816	28708.49

Amounting together to the sum of $111696.24

Out of which is to be deducted, for the daily pay and travelling expenses of the members of the Board	$343.92
For 362 shares of stock of the Banks of Virginia purchased in pursuance of a resolution of the Board	36105.00
For the expenses of the Engineer while surveying the Rappahannock, Kanawha, James and Jackson's rivers	1500.00
For stationary, printing, bookcase, &c. - -	78.87
For an assistant to the Engineer in surveying the James and Kanawha rivers	350.00
For three quarters salary of the Secretary and half year's salary of the Engineer	2750.00
For the first instalment of the state's subscription to the stock of the Dismal Swamp Canal Company	15500.00
And in execution of the act entitled an act to provide an accurate chart of each county, &c.	1550.00
	$58177.79
And leaving a balance in the fund, on the 4th day of November 1817, of	53518.45
	$111696.24

Of the above funds, only the Little River Turnpike, the Dismal Swamp Canal, the Appomattox Canal, and the Potomac Canal stocks are, as yet, unproductive. These amount to $73661.11, and from the documents accompanying the report, it appears that part of these funds will soon become productive.

On the 12th day of November 1816, the President and Directors proceeded to the appointment of a principal Engineer, when Loammi Baldwin Esq. of Massachusetts was chosen, and we cannot give a better account of the objects and policy of the Board, than by showing how the engineer has been employed in their service.

The first object to which he was called, was the examination and survey of the Rappahannock and Rapidan rivers, for the purpose of opening the navigation from tide water at Fredericksburg, about forty miles on each stream. His report, with a plan, was made to the Board, in which the En-

gineer recommends a system of navigation for small rivers, uninterrupted and complete through the whole season, for boats carrying from fifteen to twenty tons. This, however, was considered by the Rappahannock Company as too expensive for their means, and he was again called upon by a committee of the Board, to revise his report, and reduce the estimate to a scale of navigation similar to that now used on the James River. Accordingly he made out a new estimate, by which the cost of the work was reduced to $200,000. This was perfectly satisfactory to the Board and the Company, and the Board immediately subscribed for two fifths of the stock, and the work has already been, or soon will be, commenced.

It appears that Mr. Baldwin's scheme was to erect dams across the rivers at suitable places, with locks, and thus to deepen the water over the rocks and other obstructions, and as far as possible, to convert the rivers into canals. This is certainly an excellent plan, and in many parts of our country may be adopted with more ease and safety than is generally supposed. But it will require great judgment and experience in the Engineer to determine where this system can be successfully adopted. The quantity of water which the stream discharges, its depth, width, velocity, bed, and all its physical characters must be carefully ascertained before any safe result can be predicated. In Mr. Baldwin's second report upon the Rappahannock navigation, after making the estimates with some remarks, he says,

'Upon this hasty view of the subject, I believe the two rivers in question may be made navigable for boats like those on the James River, and to carry from three to eight tons, with the sums above stated. But it is a system I would never recommend, where the resources of the country and the importance of the navigation justify such a plan as I had in view when I made my report. In that, I intended to provide for a constant and easy navigation, even in the dryest seasons, for boats carrying from fifteen to twenty tons. But as the immediate accommodation of that section of the country does not, in the opinion of the committee and those more directly concerned in the project, require a navigation upon so large a scale, the one now in contemplation may be perhaps prudently and advantageously adopted. Keeping in sight, however, the probable future extent of internal navigation through the channels of those two rivers, I should still think it advisable to make the canals at Barnett's, Mackay's, and

Richard's Mills, and the canal and basin near Fredericksburg, as at first proposed. These will be important works; and should the trade on the rivers increase, as it undoubtedly will when once begun, the rivers may be gradually improved by locks and dams, and a complete river navigation, on the best principles, in time, effected.

'On returning from my late survey from Dunlap's creek to the mouth of the Great Kanawha, I had an opportunity of viewing the James river navigation, and the manner of navigating boats through its whole extent;—so far from inducing me to think the principles on which I founded my report ought to be abandoned, the examination confirmed me more strongly in the belief that they ought to be kept constantly in view whenever navigation on small streams is contemplated.'

The next duty, to which the Engineer was called by the Board of Public Works, was the survey and examination of a route for a road and water communication between the eastern and western borders of the state. We insert the following passage from the report of the Board to the Legislature, to show the nature of the work the Engineer was directed to perform.

'The connexion between the eastern and western waters,—by extending the navigation of James river to Dunlap's creek and constructing a turnpike-road from thence to the falls of the Great Kanawha river, or by opening the navigation of Greenbrier and New rivers to the highest practicable point,—early attracted the attention of the Legislature of Virginia; our illustrious Washington was scarcely freed from the arduous service of the revolutionary war, before he called the attention of his native state to this important undertaking; the exhausted state of the country rendered it impracticable then to execute such a work, but its importance was then, and has been frequently since recognized; several views of the rivers and for a road, were had, and considerable expenditures made in effecting the latter object. In the year 1810 the Legislature directed a view of the rivers, by a number of our most respectable citizens; their very able report was laid before the Assembly, and it is believed that nothing but the intervention of the late war then prevented an effort to accomplish this great work; immediately after the return of peace, this Board was formed, and the system now in force, for the general improvement of the state, adopted. In the last annual report from this Board, this subject was strongly recommended to the Legislature; and under the fullest impression of its importance,

Mr. Baldwin, the Engineer, was directed to examine the obstructions to the navigation of James and Jackson's rivers, between the mouth of Looney's creek near Beal's Bridge and the mouth of Dunlap's creek; and the obstructions to the navigation of the Great Kanawha river, between the great falls in that river and its confluence with the Ohio river; and to report to this Board a description of such obstructions, and his opinion as to the best means of overcoming or avoiding the same; with plans and drawings and estimates of the probable expense thereof; and also to survey and mark out the best route, over which an artificial road may be formed from the mouth of Dunlap's creek on Jackson's river, to the falls in the Great Kanawha river, of competent width, and forming the smallest angle with the horizon, and to report plans and drawings thereof, with estimates of the probable expense of forming and constructing such road on the most improved modern plan, together with such information, illustrative of the subjects submitted to his examination, as might aid the Board of Public Works in forming and digesting a plan for opening an easy communication between the eastern and western borders of this Commonwealth.'

The duty assigned to the Engineer by the above direction of the Board, occupied him above three months. His report to the Board accompanies theirs to the Legislature, and fills almost thirty pages. He began his survey at Looney's creek. This is the highest point to which the navigation of James river has been opened by the James River Company, and is about two hundred and thirty miles above Richmond. From Looney's creek to the mouth of the Cowpasture river, the head of James river, the distance is over twenty-four miles, and the ascent two hundred and thirty-four feet; thence up Jackson's river to the mouth of Dunlap's creek, thirty-six miles, the ascent is a hundred and seventy feet. From the mouth of Dunlap's creek, the line for a road to the great falls of the Kanawha is nearly a hundred miles, and the Kanawha river, from the foot of the falls to its junction with the Ohio, is ninety one miles, having a fall of a hundred feet.

A water communication from the Roanoke river, across the country, to the Appomattox near Petersburg, or to the James river, has long engaged the attention of gentlemen interested in the intermediate territory, and the merchants in Petersburg concerned in the interior trade of Virginia and the northwest part of North Carolina. Upon an application of the citizens of Petersburg, the Board of Public Works directed

their Engineer to make the survey, and run the levels for a canal to connect the waters of the Roanoke with those of the Appomattox,—the expenses of the survey to be defrayed by the applicants. In examining the country over which this canal was contemplated, many difficulties presented themselves. The Roanoke, the Meherrin, the Nottoway, and the Appomattox rivers descend from the high lands in the vicinity of the Blue Ridge and the Allegany mountains, in nearly parallel directions. To open a water communication from the first to the last mentioned river, the Meherrin and the Nottoway rivers, with many smaller streams, must be crossed; and the land between them rises in high ridges, some of which, especially that between the Roanoke and Meherrin, must be tunnelled. After exploring the left bank of the Roanoke, from Goode's ferry in Mecklenburg county twenty miles to the boundary line of North Carolina, no place was found so eligible for communicating with the Roanoke, as by Miles creek, which empties into that river at Goode's ferry. Here the survey was begun, and carried over the ridge and down Mountain creek, to the Meherrin. The distance was eighteen miles, the highest part of the ridge two hundred and thirty-two feet, and the surface of the Meherrin ten feet above the level of the Roanoke. A level was then taken twenty feet above the Meherrin, and carried down the left bank of that stream to Brunswick court house, and then over the intermediate ridge between Rose creek and Sturgeon creek to the Nottoway at Cut Bank Bridge. From this place to Petersburg, there appears to be little difficulty in executing a canal, the distance being thirty miles. The whole line surveyed is about ninety miles, and the estimated expense $2,000,000. It is expected an application will be made to the General Assembly next winter for an act of incorporation. The report and plan of this survey have been made to the Board by the Engineer, and will be communicated to the Legislature and the public in their next annual report.

The next work which devolved upon the Engineer was the survey for a canal from Goose creek in Loudon county to Hunting creek near Alexandria. It was thought that a canal was practicable in this direction,—it had been a favourite project with General Washington, and zealously advocated by him. The Great falls in the Potomac, and the Little falls near Georgetown, have been made passable several years by short

canals and locks. But owing to the injudicious location and execution of those works, as well as many others on that river, the navigation is far from being good. Upon the survey for the Alexandria canal, a practicable route was found along the right bank of the Potomac river to Difficult run, which falls into the river a little below the Great falls, and from that point to Alexandria the country is so broken and uneven as to render it impracticable further. This distance is about thirty miles. The report, &c. will hereafter be communicated by the Board.

Mr. Baldwin closed his official duties, as Engineer to the Board, by his examination of the Richmond docks and the James river, for a distance of about four miles below Richmond. This duty was assigned to him by the Board, on an application of the Richmond Dock Company, who have been engaged two years in constructing a canal and docks to admit vessels to come up to the town from Rocketts, where the wharfs and shipping now are A bar below the town has been gradually accumulating, which materially injures the navigation of the river. The Engineer's report was made to the Board early last spring.

We have given this sketch of the views of the government in establishing the Board, the funds set apart and devoted to objects of internal improvement, the organization of the Board and the services in which their principal Engineer has been employed, that our readers may form a general notion of this new and important institution. Indeed, whatever view we take of the Board of Public Works in Virginia, we consider it not only honourable to that state, as being the first establishment of the kind in the United States, but also as leading the way to the most valuable, permanent and economical scale of national improvement the country is susceptible of. Like all new projects, however high and honourable their objects, this Board has met with opposition;—in the General Assembly last winter, a resolution was introduced for abolishing the Board, and transferring their duties to the Governour and Council. The reasons on which the motion was made, we deem it unnecessary to state, as the report of the committee appointed to take the subject into consideration, although favourable to the views of the mover, was rejected by a powerful majority, and the Board consequently more firmly established in the good opinion and confidence of the public.

Before we lay aside this report of the Board, we feel a strong inclination to recommend this establishment to the attention and careful examination of our readers. We shall proceed to state some of the beneficial influences, which similar institutions in every state would have upon the interior improvement of the country.

The profession of a civil engineer is scarcely known among us. Whenever any new work is to be undertaken, it is no difficult task to find men of strong minds, good sense, with a little practice and skill, to superintend the execution. Such men are numerous and generally have moderate pay. Their labours, though not always judicious, are for the most part successful; but whether the best plan has been adopted, or whether much expense might not have been avoided, excites no inquiry or criticism where so few are qualified to judge. In bridge architecture, our country abounds with beautiful specimens both in carpentry and mechanical invention. But we do not build in stone or iron, and scarcely has one wooden bridge been erected, where the plan, with the number and adjustment of parts, has been founded on purely scientific principles. Our ingenious artificers pursue the right onward path of practice, without minute investigations of the strength of materials, centre of oscillation, or the balance of forces; and it is certainly an honourable evidence of the general improvement of the people, that such men are so frequently found, and that their works are so promptly and effectually accomplished.

In hydraulic architecture, opportunities seldom arise for the application of much genius or science. To construct a canal, it would hardly be thought necessary now to employ a regular engineer. Digging a wide ditch, blasting rocks and laying a few short walls for locks, are things of every day's experience, and when one undertaking is finished, the labourers, masons, carpenters, superintendants and all, retire to their usual occupations, from which for a short time they have thus been called. All the advantages which practice has thus bestowed, are lost to the public, without one individual having acquired any information that can be useful to the community in similar works.

In the construction of roads, a proposition to employ a professed engineer would excite laughter. Every able bodied man in the community is considered as competent to such work.

and after the surveyor has staked or blazed out the line, the work is commenced by a great many individuals, and executed in as many different manners as there are contractors. Our highways, especially in New England, are certainly very good, but there are many which might have been better constructed at first, and much of the subsequent expense of keeping them in repair avoided. From this carelessness about the adoption of proper forms and materials, no good plan or safe mode of working has been adopted, nor any general fund or depository established where useful and safe information, science or practice can be procured.

Hydraulic structures in rivers and currents of water, are attended with greater embarrassments. In this branch of engineering, workmen are not so easily found. Bold and enterprising contractors, so frequently met with to undertake any part of roads and navigable canals, are too cautious to combat the subtle operation of hydraulic laws, and in no department of the profession are there so many instances of failure. But even the great faults daily committed by inexperienced and ill-informed workmen have their use. Whoever consults the works of European engineers, will perceive that the failures in labours of this kind have taught useful lessons to those who have followed the unsuccessful projectors; but knowledge thus acquired is necessarily limited in its application, and perhaps a plan altogether bad for one situation may be the best for another place near it on the same river. For the want of that union of sound science and extensive practice, which constitutes a good engineer, serious injuries to the navigation of rivers have frequently occurred. The operation of hydraulic principles is superficially understood by many people, who presume to change their effects without a single correct notion of their laws. 'Every body,' says Dubuat, 'reasons upon hydraulics, but there are few persons who understand it. Every kingdom, every province, and every city must resort to it; neither our necessity, convenience, nor luxury can dispense with the use of water; we want it in our habitations; we must protect ourselves from its ravages, cause it to move machinery which aids our weakness, decorate our abodes, embellish and cleanse our cities, augment or preserve our lands, transport from province to province, and from one end of the world to the other, every thing which necessity, taste, or luxury has rendered precious to man; we

must confine great rivers, change the beds of streams, dig canals, and build aqueducts; and what is the consequence? Why, for the want of principles, projects are adopted which involve great and certain expenses, where success is chimerical; works are undertaken which fail in their object; the state, provinces and companies are loaded with great expenses without any emolument, and often to their injury, or at least there is no proportion between the cost and the benefit which results from them.'

From this view of the manner in which the profession of an engineer has been kept from rising to the notice and encouragement its importance demands, we may perceive why so little information can be procured, and so few men found capable of directing costly and difficult works. Few minds are competent to the arduous studies, critical observation and philosophical mechanics, on which alone a valuable artist can be formed. No school has been opened, no board of works created, no society of engineers established, nor any constant, profitable employment offered in the United States for the encouragement of this highly valuable but unaspiring profession. Whatever experience has or might have taught, is scattered among a multitude of ingenious and contriving men, without any one having been employed long enough to rise into prominent reputation. In the acquisition of science still fewer are to be met with. Many little tracts are published and read upon different subjects, where a hasty and superficial knowledge only can be gathered, and all that is thus acquired rises only a little above the ordinary contents of newspapers. The valuable experiments and analytical investigations of French and English philosophers and engineers are scarcely known in this country, and whoever would make the profession a study, must be at great expense in collecting books. The works of the early Italian writers must be followed with great caution; the French abound with elegant and deep mathematical analyses, and the English books upon the subject are few and incomplete.

Italy is traversed by a multitude of rivers and torrents, which are extremely liable to overflow and ravage the lands in their vicinity. Great pains were early taken to remedy these evils, and give to the agriculture and husbandry of that country a protection against those sweeping currents. Many philosophers and engineers were occupied for years in in-

vestigating the laws of hydraulics and currents of water, and a collection of all the treatises of various authors was published at Parma in 1766 and 1768, in seven volumes, 4to, entitled, 'Nuova raccolta d' autori che trattano del moto dell' acque.' In this work are found the investigations, experiments and disputes of learned men upon this important national subject. Castelli, Montanari, Guglielmini, Manfredi, Guido Grandi, the Marquis Poleni, and others, devoted their high talents and extensive acquirements to this interesting but neglected branch of political economy. Their labours, however, were not always successful, their principles were often erroneous, and the results of the plans they recommended were sometimes the reverse of what was desired and expected. In France, the profession has been filled by able men, who united all the advantages of refined education to the most profound mathematical science. The honours and confidence bestowed upon them by the government, shew in what estimation their characters were held, and it offered both reward and fame to the engineers employed in public service. Belidor, De Prony, Gauthey, Perronet, De Cessart, as well as many other professed engineers, have been ably supported in their progress by the occasional illustrations and learned researches of D' Alembert, Bossut, Dubuat, Carnot and other eminent characters in the higher branches of science. In England, engineers have more recently been brought into activity and honour. Few works upon the subject, however, have been published, and whoever endeavours to gain any knowledge from English publications, must glean it from many little occasional works. Brindley left nothing in print for posterity. Smeaton's reports are very valuable, and afford more information upon hydraulic labours than any other English book.

Under these circumstances, there is little to flatter the hopes or awaken the pride of any one disposed to follow the profession; and to these difficulties may be ascribed the want of scientific, safe, practical, civil engineers in the United States. 'In examining what degree of merit is due to the labours of engineers, it will doubtless be allowed, that, among the services rendered to society, there are few more valuable than theirs. The establishment and perfecting of communications, the execution of which is submitted to their care, is really an object of primary importance, consid-

ered either in relation to their influence upon commerce, upon manufactures and the arts, or the immense sums appropriated to them by government. In executing the works necessary to such communications, nature often presents great obstacles, in surmounting which we must combine all the resources of science and art. Hence, extensive knowledge and profound studies are necessary to engineers. There are few discoveries in the physical and mathematical sciences, from which they cannot draw useful aid. These discoveries should be familiar to them; they should learn to apply them with judgment, and of course be thoroughly acquainted with the sciences to which they relate. But study alone, however extensive it may be, is not enough; without experience it is of little value; and the experience of a whole life is scarcely sufficient, in this respect, to form an accomplished artist.'*

It is scarcely two hundred years, since it was discovered, by the aid of experiment, what is the duration, the quantity and the velocity of the efflux of water through any orifices; and when it was found that the velocity of the issuing fluid was proportionate to the square root of the head, many philosophers attempted to verify this surprising fact, and to apply it to the movement of water under all circumstances. This principle caught the attention of Varignon, Mariotte, Guglielmini and others, who immediately fixed it as the basis of hydraulics. Reasoning from this assumption, Guglielmini calculated the velocity of the filaments of water in rivers at different depths, which led to the conclusion that it was greatest at the bottom, and gradually decreased towards the surface, where the velocity was nothing. Upon this hypothesis he calculated the discharge of the Danube. But he, as well as Mariotte, soon found from observation and from the experiments of the last, that important circumstances in currents of water, either in conduit pipes, canals or rivers, had been overlooked in establishing this theory, and that the friction of the bed, the viscosity of water, &c. must influence the results of all calculations upon the subject.

M. Pitot, in his treatise upon the Principles of Hydraulics, established a fundamental principle upon the intensity of the friction of water, and in a memoir of the Academy of Sci-

* Navier; Eloge Historique de M. Gauthey, Inspecteur général des Ponts et Chaussées, membre de la Légion d' honneur.

ences, 1728, he applies the law of the ratio between the increase of the volume and superficies of solids, to the theory of friction of fluids in pipes, and concluded that, at equal velocities, it was in the inverse ratio of their diameters. Mr. Couplet afterwards made experiments upon the conduit pipes of the water works at Versailles, and though very few and imperfect, these experiments served to shew the great effects which friction causes in the flowing of water. On account of the limited scale on which his inquiry was conducted, the theory he has deduced, as well as that which Belidor substituted, is of little value. Inconclusive and unsatisfactory as all the labours of these and other learned men in Europe were upon this subject, they served to keep alive the spirit of inquiry, until it seized the attention of those celebrated geometricians, Daniel Bernoulli and d' Alembert, who subjected the movement of running water to the test of the most learned and complicated analysis. They began with a very simple case, and examined the discharge of water through small orifices, where the friction is the least evident. The result of their labours differed considerably from that of Newton, who had preceded them; neither is entirely confirmed by experience; and philosophers were left with the conviction only, of the great difficulty of subjecting the motion of fluids to the analytical process.

In this state of the science, M. l' abbé Bossut took up the subject, and, convinced of the importance of experience in such delicate researches, he made, with his usual sagacity and astonishing exactness, a great many observations upon the movement of water flowing through different kinds of apertures, through pipes of different lengths and diameters, and in artificial canals. His work, Traité Théorique et Expérimental d' Hydrodynamique, contains many useful remarks upon rivers &c.

Next to the labours and researches of M. l' abbé Bossut, in its value and application to this science, is the work of Dubuat on the Principles of Hydraulics and Pyrodynamics. Finding that all the experiments and investigations of his predecessors came short of the clearness and accuracy, to which he thought the science might be carried, and that the laws of the motion of fluids had not been developed in their full extent, Dubuat sought to solve the problem which appeared to him, as he says, 'to be the key to hydraulics,'—

that is, to determine the velocity of a current, whose slope and bed are given. 'No one can deny that if two rivers have the same depth, the same breadth, and the same slope, and flow over homogeneous beds, their velocities will in no respect differ; but if we change either of these accidents, the velocity will increase or diminish, without ceasing to be uniform. Hitherto, no known theory teaches us how, from these data, to calculate the velocity; and the velocity being unknown, the discharge must remain unknown also; consequently, we cannot foresee the success of any operation upon the beds of rivers, nor solve a single problem which relates to it.'*

Animated by the new views of this important branch of science, which the admirable work of Bossut had opened, Dubuat reflected deeply upon the principles of the laws of uniform movement, and the accelerating and retarding causes which produced it. He considered the slope of the surface of rivers as the only effective cause which produced their motion, and that, if there were no resistances, it would go on increasing without limitation. But rivers are checked, and become uniform in their motion, by certain obstacles, and he justly concluded that these obstacles are the friction upon the bottom and sides, and the viscosity of the fluid. The last gives rise to two species of resistances; one is the internal motion of the parts of the fluid whose mobility is imperfect; and the other arises from the natural adhesion between those parts and the beds in which they move. These two retarding causes acting together, soon become equal to the accelerating force, and produce in all streams a uniform movement. Hence, Dubuat fixed the following evident and certain principle as a law, as old as the creation of rivers, which is the key of hydraulics and the basis of all uniform motion, viz.—'When water flows uniformly in any bed whatever, the accelerating force, which compels it to move, is equal to the sum of the resistances it encounters, as well from its viscosity as its friction on the bed.' He made use of the experiments of Bossut, and adopted a formula applicable to the solution of many beautiful and useful problems. His Principles of Hydraulics was completed in 1779.

Still this new theory was not perfect, nor were the experi-

* Dubuat; Principes d'Hydraulique et de Pyrodynamique, vérifiés par un grand nombre d'expériences faites par ordre du gouvernment. Discours préliminaire. En trois volumes. Paris 1816.

ments, even those valuable ones made by Bossut, yet satisfactory to Dubuat. He wished to render the theory more useful to the many wants of society, and to make, for this purpose, experiments, which should supply the deficiency left by those who had gone before him. His new treatise was shewn to M. de Fourcroy, director of the royal corps of engineers; it was admired by him and other public ministers, and finally shewn to the king. The consequence was, the minister of war issued an order for the expenses of a new series of experiments; an annual fund was appropriated for this purpose, and, in the years 1780, 1781, 1782 and 1783, Dubuat, assisted by Messrs. Dobenheim and Benezech de Sainte-Honoré, officers in the royal corps of engineers, made those experiments, on which is founded the best and most extensive treatise upon hydraulics the world has yet seen.

Among the authors who may be added to the above list, and who have been occupied both in study and experiments upon the science of hydraulics as connected with the profession of engineers, are Prony, Bossut and Viallet, Girard, Ducrest, Carnot, &c.* We could extend the list very far, and give our readers an interesting summary of the authors' labours; but our object is only to exhibit the important and difficult course that must be pursued by an engineer, who would make himself useful to the public. Upon the subject of works to be constructed in sea-ports and harbours, on rivers, &c. we shall notice two or three books, which will be found extremely valuable. Smeaton's History of the building of the Eddystone lighthouse is full of minute details, where much information is found applicable to constructing masonry in

* Recherches Physico-mathématique sur la Théorie des eaux courantes. Par R. Prony, membre de l' Institut national et de la Légion d' honneur, Directeur de l' Ecole des ponts et chaussées, 4to, 1804.—Recherches sur la construction la plus advantageuse des Digues. Ouvrage qui remporta le prix quadruple proposé par l' Academie des Sciences, Inscriptions et Belles Lettres de Toulouse, pour l' année 1762. Par les citoyens Bossut et Viallet. Nouvelle edition, 1800.—Essai sur le movement des eaux courantes, et la figure qu'il convient de donner aux canaux qui les contiennent; Par P. S. Girard, ingénieur en chef des ponts et chaussées, membre de l' Institut d' Egypte, 1804.—Traité analytique de la rèsistance des solides et des solides d' égale résistance, &c. par P. S. Girard 1798.—Vues nouvelles sur Les Courantes d' Eau, la navigation Intérieure et la Marine. Par C. L. Ducrest, 1803.—Principes Fondamentaux de l' E'quilibre et du Movement; Par L. N. M. Carnot de l' Institut national de France, de l' Académie des Sciences, Arts et Belles-Lettres de Dijon &c, 1803.

the sea and places exposed to the violence of waves. In 1812, a collection of his reports, made on various occasions in the course of his employment as a civil engineer, was published in three vols. 4to, with numerous plates. This work contains his opinions, directions, and experiments upon canals, harbours, improvements in rivers, bridges, mills, &c. and as they are founded on enlightened science and extensive practice, are very useful. In the course of his occupation as a civil engineer,—nearly forty years,—he was often called to revise the plans proposed by other artists, and to correct the faults and difficulties which arose under the superintendence of inexperienced workmen. He was long at the head of English engineers. He first collected a number, and formed a society. Their first meeting was in 1771, but it was dissolved in 1792 on account of the treatment Mr. Smeaton had received from one of the members. The misunderstanding was removed by an apology to him, and a new association, Mr. Smeaton agreeing to be a member, was formed the same year, which has ever since continued under the name of The Society of Civil Engineers.

De Cessart's treatise upon hydraulic works* is full of instruction for practical engineers. It contains the details of all the labours either designed or directed by him, such as bridges, ports, harbours &c. The well known Breakwater at Cherburg was planned and built by him. Experience has since shewn that his project for sinking the line of cones, which served as the base of the Breakwater, was unnecessary and involved useless expense. Many of the cones have burst open, and the work has since been repaired by throwing in large masses of detached rock, so that its stability is now certain. In constructing the beautiful bridge at Saumur, an exact register was kept of every part of the labour and expense. Every stroke of the pile-engine was noted in a table, with the time, the distance the pile sunk, &c. all set down in columns,

* Description des Travaux Hydrauliques de Louis Alexandre de Cessart, Doyen des Inspecteurs généraux des ponts et chaussées, un des Commandans de la légion d' honneur, membre de plusieurs Académies et Sociétés savantes. Ouvrage imprimé sur les manuscrits de l'auteur. Deux volumes 4°, avec soixante-sept planches, Paris, 1806. The high reputation De Cessart had, both with the government and engineers, is exemplified by the list of subscribers, so seldom seen in French books, where are found the names of above three hundred engineers belonging to the school of bridges and roads.

from which the expense of the piling for the foundations of the piers was calculated. To engineers these data are useful.

In reading Gauthey's treatise* on bridges, architects, engineers, and men of science will find instruction. The school of bridges and roads was established by Trudaine in 1747, and the celebrated engineer, Perronet, was placed at the head, whose eminent talents and amiable temper are still fondly remembered by his pupils. To the science and labours of the various members of this school, France is indebted for some of the finest and most useful works of art. The activity, zeal, and high qualifications of the first director, have been preserved to the present day, by a just appreciation of the mutual dependence between national improvement and individual industry, in the application of science to the labours of man. M. Gauthey at first experienced some difficulty, on account of his poverty, in being admitted an eléve, to which his early ambition impelled him. He soon overcame all obstacles, and was made professor of mathematics. He had afterwards the superintendence of many works, such as bridges, canals, &c. The first part of his treatise contains an account of all the great bridges, ancient as well as modern, with the kind of arches, materials, manner of construction, form and dimensions of the piers, by whom and when built, &c. The marble bridge at Florence, and the Rialto at Venice, also of marble, were built by Michael Angelo.

In the theory of arches and domes, Mr. Gauthey was well instructed, and a remarkable instance of the correctness of the theory was shewn by him, in defence of the plan which Soufflot had given for the church of Sainte-Genevieve at Paris. The foundations of that superb edifice were laid, and all parts of the building raised a little above ground, when fears began to be entertained about the sufficiency of the piers and arches intended to carry the magnificent dome, which the architect had designed. The public, as well as artists, were alarmed, and all Paris was agitated. Gauthey came forward in aid of his friend and master, and demonstrated that the piers were sufficient to resist the thrust and weight of the dome. Experiments were made by Soufflot, Perronet and Gauthey,

* Traité de la Construction des Ponts. Par M. Gauthey, inspecteur général des ponts et chaussées, membre de la Légion d'honneur. Publié par M. Navier, ingénieur ordinaire des ponts et chaussées. 2 volumes 4to, 1809.

which satisfied themselves and the public that no danger was to be apprehended, as the surface of the piers and arches was more than sufficient to sustain the weight required. Unluckily, Soufflot resolved to enlarge the dome, in consequence of which the public were again alarmed by the fracture of some of the stones in the piers, and it was thought they would be crushed by the weight. Gauthey again tranquillized the public mind, by shewing that this was the result of bad workmanship in the masonry, and that it would soon come to its rest. This was the fact, and the church of Sainte-Genevieve (now the Pantheon) stands as safe as any church in France.

We have given the foregoing sketch of the history of hydraulics and of hydraulic architecture, to shew how the labours of engineers and other experimentalists have been appreciated in Europe, and the importance of public establishments to bring the science into practical use. Without a knowledge of the theory of rivers, we hazard much in setting about any of the works usually built in them. If we have occasion to build dams; to improve the navigation of rivers; build piers and abutments for bridges; construct weirs or overfalls; contract the bed or deepen the channel; defend lands from freshes; construct dikes for reclaiming our salt-marshes from the sea, or other purposes; erect mills; calculate the quantity of water a river, pond, or other source will furnish; ascertain what is the effect of a dam or other obstruction upon the stream, either above or below it; fix the dimensions of a conduit pipe to bring water to towns or houses; change the direction of currents; remove bars or other obstructions, which injure river navigation; determine the dimensions of canals, and the forms of boats to navigate them; if we wish to do any of these and many other things of the kind, we must go back to scientific researches and experiments for a satisfactory solution. Let any man attend our courts of law, and witness the trials arising under the mill act, as it is called, in Massachusetts, and he will see how little is understood by the parties, their witnesses or counsel, of the real cause of the evil, or the laws of hydraulics, which alone can furnish a correct decision. For want of extensive acquaintance with this science, many bridges, having been injudiciously placed and erected over rivers, have been swept away by freshes, and examples might easily be named,

where attempts to remove sand-bars and improve river navigation, have not only failed, but greater evils have been created by the unsuccessful trials.

We shall now recur again to the Board of Public Works in Virginia, and recommend it, as a novel experiment to be sure, but an experiment, in our opinion, admirably calculated in all its relations to society, as a model for similar institutions in each state, that would combine and concentrate all the science and experience relative to civil engineering. We will not inquire whether the Virginia Board is, in all respects, founded on the best plan, and organized in the best manner the nature of the establishment would admit. It is new, and, probably, has not yet come to its proper bearing, either in its labours, its tendency, or public opinion;—therefore, all criticism would be premature and unfair. As far as we can judge from the eminent and enlightened men, who brought forward this subject in the Virginia Legislature, and from the caution, wisdom, activity and perseverance, which have marked the proceedings of that Board hitherto,—we speak from personal acquaintance with most of the members, as well as with the acts of the Board,—we have no hesitation in believing it will be extremely useful to that commonwealth, that it is in every respect worthy of public confidence, and of being imitated in every state in the union.

Let us then suppose a Board of Public Works, or some establishment of the kind, to be founded in Massachusetts, with powers and duties like those given to the Virginia Board; and who can doubt of its utility and extensive influence? Some of the leading advantages we will state, because we are persuaded that there are many intelligent men in our legislature, who would take pride in advocating and promoting any rational plan for improving the condition of our country.

In the first place, there would be, at least, one engineer of the commonwealth, who might devote all his time to the study and practice of his profession, whose salary and occasional employment by private companies or individuals, would give him a sufficient and honourable support. There would thus be a professional character, to whom the public might confidently resort for surveys, plans, estimates, &c. in all great undertakings and public buildings.

Secondly, the office of the Board would collect all the records, reports, plans, &c. of canals, roads, docks, and every

species of labour connected with internal communications. Surveys of towns and roads, all the documents relative to canals either begun or contemplated, schemes for the improvement of rivers either for navigation or manufactures, and plans of bridges, docks, &c. might be collected in one place, from which could be obtained important information concerning the commercial and internal improvement of the state.

Thirdly, the Board should gradually collect books and instruments connected with the science and practice of engineering. Neither of these are possessed by individuals in great numbers, and if any person seeks for them in the shops or book-stores in the United States, he will be disappointed. He must import them for his own use at great expense. Small appropriations of money for these several objects can surely be no objection in the beginning, but a beginning is indispensable. We are not advocating the cause of any individuals or class of men, for we have no engineers; we wish only to excite inquiry and to produce in the public mind a conviction of the advantages that must result from the plan we recommend, and to place within reach of the community all the knowledge and practice of the science, if we are unwilling to encourage engineers.

The importance of the establishment we recommend must be acknowledged, when we consider the qualifications which every good engineer ought to possess. He should be thoroughly acquainted with every branch of mathematical science, and have a facility in applying calculations to the various objects of his pursuits. A knowledge of the principles of natural philosophy and of theoretic and practical mechanics, ought to be familiar to him. In the course of his practice, he will be called to examine the nature of the soil, and to choose the most eligible route or place, over which a canal is to be made or other work erected, and to do this with ease to himself and advantage to his employers, he should possess a general geological knowledge of the country, and be able to distinguish the different strata, and to sketch the prominent features of the line. He must have a correct view of the geographical and commercial character of the districts to be affected by the canal, and be able to calculate the probable result of his labours upon agriculture, manufactures and trade. An accomplished engineer should be at no loss to determine what materials should be employed, their price, the

facility of procuring them, and what quantities either of stone, timber, mortar, &c. should be provided. He must also be a competent judge of the workmanship, in carpentry, masonry and other manual labours usually performed in engineering. To all these requisites, should be joined an easy temper of mind, unshaken integrity, firmness and perseverance, that he may secure the respect of those under his direction, and the confidence of his employers. Notwithstanding his industry, care and ingenuity, difficulties and embarrassments will occur, which must task his highest efforts; and a ready application of expedients and a fearless spirit of invention regulated by sound science, good sense and experience, can alone enable him to surmount them. These are some of the qualifications of a consummate artist, and perhaps few men, with all the advantages of study and long practice, can acquire them, without a natural tact or cast of mind for the profession.

Many of our readers will probably be disappointed, in closing this long review, not to have found some notice of the many great and important works begun or contemplated in the United States. But we have not been unmindful of them; we view the extensive canals and other plans for improving the country, with peculiar pride and pleasure; and, trusting in the liberality and public spirit which have traced the lines of internal communications, we have ventured to recommend a system which will enlarge our scope of national policy, and provide a new scale of economy for regulating an immense expenditure of public money.

ART. II.—*Considérations sur les principaux évenéments de la révolution Française, ouvrage posthume de Madame La Baronne de Stael, publié par M. Le Duc de Broglie, et M. Le Baron de Stael.* 3 tomes 8vo; Paris, 1818.

THE discussion of the causes of the French revolution has employed much learned speculation. A people patriotic and loyal to enthusiasm, were led to overthrow a government which had existed without considerable change for many centuries, to bring to the scaffold a king whom they loved, and what is more astonishing, a queen, whose beauty was their admiration, whose faults might have been pardoned without